SOCIETAL LIFE CYCLE ASSESSMENT

Social life cycle assessment of palm oil biodiesel: a case study in Jambi Province of Indonesia

Yosef Manik · Jessica Leahy · Anthony Halog

Abstract

Purpose This study aims to investigate the social implications of palm oil biodiesel via a case study using a life cycle assessment framework.

Methods The case study was conducted in Jambi Province of Indonesia and involved several stakeholders, such as value chain actors, employees, local community members, government, and nongovernmental organization representatives related in palm oil industry. The assessment was carried out using social criteria developed by adopting the Society of Environmental Toxicology and Chemistry/United Nations Environment Programme Code of Practice, supplemented by an expert survey, and supported by literature review. Stakeholders' perspectives were evaluated by determining the gaps between expected and perceived quality of each social criterion, which are gauged using seven-point Likert scale.

Results and discussion Twenty-four social criteria were developed and aggregated into five social impact categories: human rights, working condition, cultural heritage, social–economic repercussion, and governance. These criteria have been weighted, useful for further application in multicriteria decision analysis. The results of the stakeholders' survey reveal the critical social hotspots, which are the issues within the impact categories of working conditions and cultural heritage.

Conclusions In order to achieve the social equitability of palm oil biodiesel, which is an important pillar to sustainability, efforts must be put to address these social hotspots through actions in various policy level.

Keywords Social life cycle assessment · Palm oil · Biodiesel · Sustainability

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1 Introduction

Biodiesel, a renewable fuel substitute for diesel, is in demand globally. Europe and the USA are two significant markets for biodiesel. Under the new directive on the promotion of renewable energy (2009/28/EC), the European Commission established the goal of reaching a 10 % share of renewable energy in the transport sector by 2020. In the USA, under the Energy Independence and Security Act of 2007, the Renewable Fuel Standard program regulations were developed and expanded to include diesel, in addition to gasoline, and to increase the volume of renewable fuel required to be blended into transportation fuel up to 36 billion gallons (equals 1.36×10^8 m^3) by 2022.

Palm oil, the plant oil extracted from the fruit of oil palm tree (*Elaeis guineensis*) is a potential feedstock for biodiesel due to its high oil content and yield. Considering the prospect of palm oil biodiesel, major producing countries such as Indonesia and Malaysia have set up their national targets for the expansion of palm oil biodiesel production (e.g., Malaysian Biofuel Industries Act 2007 and Indonesian Presidential Instruction 2007). However, there are some challenges in establishing a stable palm oil biodiesel supply chain. Palm oil industry has been associated with several alarming sustainability issues. A recent meta-analysis review of life cycle assessment and flow analyses studies on

palm oil biodiesel has shown the significant environmental hotspots in the life cycle of palm oil biodiesel include global warming, eutrophication, acidification, toxicity, and biodiversity loss (Manik and Halog 2013).

In conjunction with the triple dimensions of sustainability (environmental, economic, and social), recent efforts are undergoing to broaden existing impact assessment studies to account more criteria relevant to the 3Ps—prosperity, people, and planet. This implies the importance of evaluating the social and economic impacts in addition to environmental impact studies (Halog and Manik 2011; UNEP-SETAC 2011; Heijungs et al. 2010). Guidelines in performing a socio-economic life cycle assessment (S-LCA) as a complement to environmental LCA within the context of sustainable development have been published by the United Nations Environment Programme (UNEP-SETAC 2009). Unlike the environmental impacts, many social impact indicators are not easily quantifiable. Thus, one way to develop the social impact criteria is by conducting stakeholders' analysis at local, national, and global levels and, then, employing a scoring system to help facilitate the assessment interpretation, relating the information to performance reference points (Benoit et al. 2010). However, efforts are underway to provide global database that eases the data collection burden in social life cycle assessment (SLCA) studies. One of them is being initiated by The Sustainability Consortium with the current Social Hotspots Database (Benoit-Norris et al. 2012)

The goal of this study is to assess the social implications of an existing palm oil production system. The work could disclose the hotspots in social sustainability aspect which is useful for design of strategies and policies to support the development of sustainable palm oil biodiesel. The following specific questions will be answered to meet the goals of this research:

– What are appropriate social criteria that should be used to assess the sustainability of biofuels, particularly palm oil biodiesel life cycle?
– How do stakeholders appraise the achievement of those criteria based on their own experience in the selected case?
– What are the social sustainability hotspots within palm oil biodiesel that needs further research and policy?

This study took place in Jambi province, Indonesia in September to October 2012. This area was chosen considering the extent of forest conversion into numerous land-use allocations, particularly into palm oil plantations in that region (Margono et al. 2012). The scope of this study covers all stages of palm oil biodiesel supply chain that exist in the case study area, which covers the land clearing, oil palm plantation, palm oil milling, and transportation of crude palm oil (CPO) from palm oil mill to sea port. Hence, the biodiesel conversion process in the importing countries is excluded in this study. Although the conversion process from CPO to palm oil

biodiesel does not exist in the case study area, the selection of this area is significant with respect to the palm oil biodiesel as a product of interest, considering that land occupation, cultivation, hauling, and milling processes play a decisive role in the entire palm oil biodiesel supply chain.

The function of the assessed product system is to produce palm oil biodiesel. However, the SLCA presented here works with information about the attributes or characteristics of processes, which are not relevant to express per unit of process output. Such information is therefore not summarized per functional unit when aggregating information across the life cycle.

2 Methodology

The methodology of this study consists of several steps. The steps are defining the goal and scope, developing and weighting the criteria, assessing the biodiesel system based on the criteria, and scoring the assessed system (Fig. 1). While the goal and scope have been stated in the previous section, other steps within the methodology are explained in the following subsections.

2.1 Developing and weighting the criteria

In order to develop the social impact criteria in this study, we adopted the criteria provided by Society of Environmental
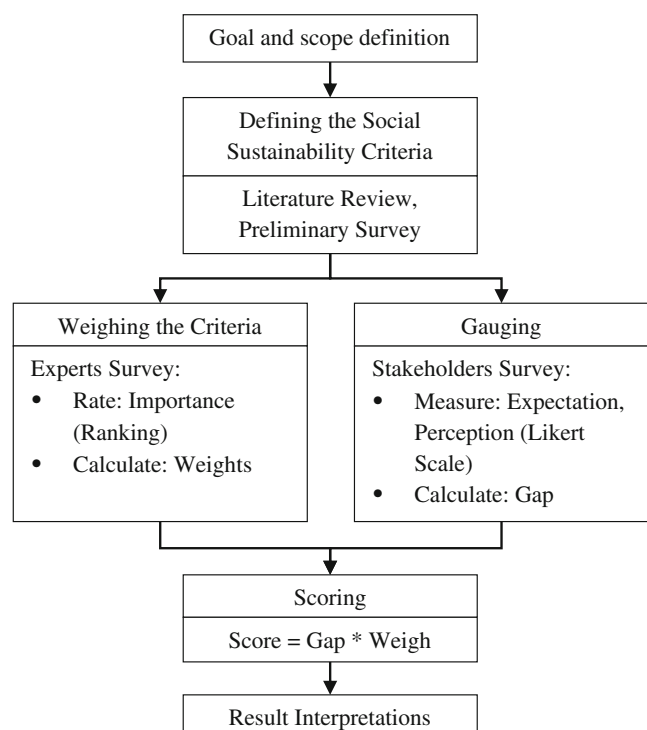
Fig. 1 Framework of research methodology

Toxicology and Chemistry (SETAC)/United Nations Environment Programme (UNEP) Code of Practice (UNEP-SETAC 2009), supplemented by a survey, and reconciled by literature review. The survey involved a panel of experts and decision makers in the palm oil industry in Indonesia. Experts were selected based on their insights in palm oil biodiesel issues. The panel consists of representatives from academia, social/environmental activists, members of nongovernment organizations (NGOs), and governmental agencies with relevance to palm oil biodiesel. The reviewed literatures are Roundtable Sustainable Palm Oil (RSPO) Principles and Criteria (RSPO 2007), Cramer Criteria (Cramer 2007), Labuschagne and Brent (2006), Weidema (2006), and Buchholz et al. (2009).

In view of multicriteria decision analysis, it is beneficial to apply a weighting system to these criteria based on experts' evaluation. This weighting process was performed using a questionnaire that allows experts to assign direct ranking on every criterion and impact category according to their importance. The questionnaire and formulas used in weight calculation process are provided in the Electronic supplementary material (ESM).

Thirty experts participated in this weighting process. An expert is defined as a person who has an understanding of the policy issues in oil palm biodiesel. As much as possible, the selection of the experts avoided the participation of those who have conflict of interest in palm oil biodiesel (i.e., those who own oil palm plantation, members of society with land dispute issues). This panel of experts consists of representation of academia, government agency, NGO, community leaders, and general public; every group is represented by six people to ensure the balance of the opinion within each group of the panel. In collecting the data, some experts filled the paper questionnaire and accompanied in person, while others filed out the electronic version of the questionnaire sent by e-mail, which still opened the opportunity for them to ask any questions related to the survey.

In accordance with the questionnaire given as ESM, for each section of the questionnaire the participant were asked to rank the criteria from 1 to n, where n is the numbers of impact categories/criteria in that particular section; 1 means very important and n means least important. Later on for the weighting calculation purpose, this ranking was turned backwards, in which the most important is marked as n and the least important as 1. The weights of each impact category or criterion were calculated using the mathematical operations given in the part B of the ESM. The result of this criteria development and weighting is a set of 24 weighted social criteria aggregated into 5 social impact categories: human rights, working conditions, cultural heritage, socio-economic repercussion, and governance (Table 1).

2.2 Gauging the stakeholders' perspective

There are four types of the stakeholders involved in this survey: (1) value chain actors: these are growers, transporters, and mill owners. (2) Workers: these are employees in palm oil biodiesel supply chain, such as plantations, mill, and hauling service. (3) Local community: These are people who live in radius of 10 km from the nearest value chain unit; they are considered as directly affected community. (4) Society: These are general public (including community leaders and NGO members) who live in the region where palm oil industry exist and have understanding in issues on palm oil business, but do not have a conflict of interest: they are considered as indirectly affected community. In reality, it is possible to find people with overlapping stakeholder role, for instance a worker can also be a part of local community. However in this survey, such participants are excluded to avoid the biased of point of view.

One hundred and twenty subjects participated in this survey. Each type of stakeholder was represented by 30 participants, a conservative minimum sample size to ensure sufficient data for each stakeholder group. Participants were selected randomly. Prior to the interview, the participants verified that they must be at least 18 years old and the interviewer had them read the consent letter. All the participants from workers, local community, and society groups filled out the paper questionnaire and were attended in person by the lead research. In some instances, an interpreter delivered the questions in the indigenous or local native language. The local native language spoken by community members is slightly different to Bahasa Indonesia, the language used in the questionnaires. For the participants form value chain actors group, some filled the paper questionnaire and accompanied in person, while others filed the electronic version of the questionnaire sent by e-mail.

For each criterion, the participants were asked a pair of questions: one question to gauge their social expectation, and another one to gauge their social perception. The social expectation questions were designed to explore the stakeholders' expectation about social aspects in palm oil biodiesel industry related to their role as stakeholders; what they think is important/unimportant according to their opinion. The social perception questions were designed to explore the stakeholders' perception about the actual state of social aspects in palm oil biodiesel industry they previously rate; how they perceive the current practice according to their experience. Both social expectation and perception were gauged using seven-point Likert scale. As an example, one of the criteria is the impact on the access to the material resources (criterion C6). The pair of questions for this impact was: "Using the scale from 1 to 7, where 1 means unimportant and 7 means very important, how do you rate the importance of the access to material resources?" and

Table 1 Impact categories, criteria, and their weights

| Impact categories	Weight	Criteria	Label	Weight	Overall weight	Relevant stakeholder
Human right	0.211	Free from the employment of child labor	A1	0.283	0.060	Workers
		Free from the employment of forced labor	A2	0.356	0.075	Workers
		Equal opportunities, free from discrimination	A3	0.361	0.076	Workers
		Sum		1.000		
Working condition	0.213	Freedom of association and collective bargaining	B1	0.118	0.025	Workers
		Fair salary	B2	0.311	0.066	Workers
		Decent working hours	B3	0.200	0.043	Workers
		Occupational health and safety	B4	0.231	0.049	Workers
		Social benefit	B5	0.140	0.030	Workers
		Sum		1.000		
Cultural heritage	0.202	Land acquisition, delocalization, migration	C1	0.147	0.030	Local community
		Respect on cultural heritage and local wisdom	C2	0.147	0.030	Local community
		Respect on customary right of indigenous people	C3	0.151	0.031	Local community
		Community engagement	C4	0.133	0.027	Local community
		Safe and healthy living condition	C5	0.145	0.029	Local community
		Access to material resources	C6	0.133	0.027	Local community
		Access to non-material resources	C7	0.091	0.018	Local community
		Transparency on social/environmental issues	C8	0.052	0.010	Local community
		Sum		1.000		
Socio-economic repercussion	0.242	Contribution to local employment	D1	0.231	0.056	Society
		Contribution to economic development	D2	0.256	0.062	Society
		Food security	D3	0.202	0.049	Society
		Horizontal conflict	D4	0.196	0.047	Society
		Transfer of technology and knowledge	D5	0.116	0.028	Society
		Sum		1.000		
Governance	0.131	Public commitments to sustainability	E1	0.272	0.036	Value chain actors
		Fair competition	E2	0.383	0.050	Value chain actors
		Free from corruption	E3	0.344	0.045	Value chain actors
		Sum		1.000		

"Using the scale from 1 to 7, where 1 means totally disagree and 7 means totally agree, how do you rate the statement that the actual process of palm oil biodiesel is ensuring the access to material resources?"

Final stakeholders' perspectives were appraised by determining the gaps between expected and perceived quality of each criterion, which is the difference between social perception and expectation. If the gap equals zero, the actual state of social aspect exactly matches the stakeholders' expectation. If the gap is positive, the actual state of social aspect is exceeding stakeholders' expectation; if the gap is positive, that means the case is the opposite. Later on, these gaps will be multiplied with the weight of each criterion,

summing up to obtain a final score useful for "apple-to-apple" comparisons with other product system(s).

3 Results, interpretation, and discussion

Results from the survey of stakeholders' perspectives are shown in a radar chart showing the average gap for each impact category (Fig. 2). Additionally, results for individual criteria are provided as supplemental information. The straight line in the chart reflect a circumstance when the perceived condition meets the expectation (i.e., gap=0), while dotted line in the chart reflects the stakeholders'
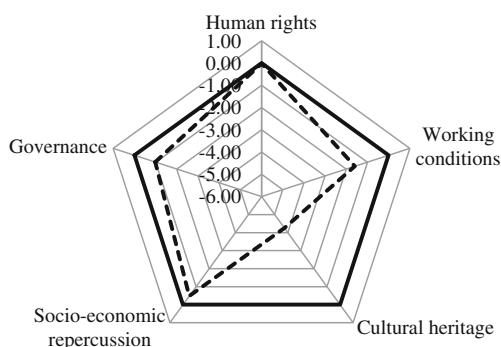
Fig. 2 The stakeholders' perspective in a radar chart

perception during this study. It is clearly seen that two impact categories (working condition and cultural heritage) have much wider gaps comparing to the others. The human rights impact category seems to have no gap, while the socio-economic repercussion and governance impact categories show relatively narrow gaps. The overall score of the assessed system, which is the sum product of the gap and weight of each criterion, is −1.50. This result implies that stakeholders' overall perception on the social impacts of the assessed product system is lower than their expectation. The issues on each impact category will be discussed in more detail in the following subsections.

3.1 Human rights

The average gap of −0.02 in the human rights impact category confirms that there is no significant difference between expected and perceived condition. That means this study does not reveal any major issue in three human right indicators in the case study area; in terms of the practices of employment of child labor, forced labor or in any form of discrimination in the investigated palm oil biodiesel value chain.

3.2 Working conditions

With an average gap of −1.60, it is found that the perceived condition does not meet the expectation in working condition. As the gaps in the criteria level suggested, freedom in association and collective bargaining (criterion B1), fair salary (B2), and social benefits (B5) should be highlighted as the most perceptible issues in this impact category.

The issues regarding working condition is strongly correlated to situations where many of the jobs created in palm oil plantations and mills are for casual day laborers, which is particularly vulnerable to being paid in low wages, lacking of job security, and with minimum legal protection. In an interview during this field research, a casual day laborer reported that she receives a daily wage for IDR 40,000.00, a value equivalent to USD 4.20, for various plantation work,

ranging from harvesting the palm fruit using pole and knife to spraying fertilizer and herbicides, without any other protection or benefit such as maternity leave, housing, insurance plan, pension, etc. This wage is below the current minimum wage set by the provincial authority, which per Governor Decree no. 5621/2011, the provincial minimum wage for the Province of Jambi for 2012 is IDR 1,142,500.00 (equivalent to USD 120.00). Permanent workers interviewed during this research confirmed that despite working for the company for 3–5 years, their wages are still set at the minimum allowable level.

Other concern in the working conditions category is the freedom to form unions and for collective bargaining. Casual day laborers reported that they are discouraged from participating in any form of workers union, a condition which results in the awfulness in their working condition.

3.3 Cultural heritage

As seen in Fig. 2, cultural heritage is the impact category with very wide gap (−4.25) between perception and expectation. In fact, this is the lowest impact category among the impact categories in question. The issue regarding cultural heritage/community development must also be understood from the history of the forest conversion in Indonesia. The land acquisition of forest is legalized by the enactment of the Forestry Act of 1967 that claim the state ownership over all forests in Indonesia without consideration of customary rights and local traditions. This policy technically denies the existence of forest dwelling among indigenous groups.

Prior to massive conversion, the forested regions in Jambi area, as well as other regions in Indonesia were home to a large number of indigenous peoples. *Orang Rimba* and *Batin Sembilan* are the tribal communities with particular relevance to this case study area. People of these tribes have inhabited the rainforest of Jambi for centuries. Traveling in tight-knit family groups, fishing, hunting, and collecting nontimber forest products such as honey, rattan, and herbs are their way of life for generations. In a personal interview, members of the tribal communities, reported that the tribes has become marginalized as soon as the forest they used to dwell was opened for plantations; not only do they lose their ground, intoxicated by the polluted water, but also experience loss of the intangible cultural heritage.

During the interview, some community members shared their experience being the victims of palm oil expansion in their territory. A member reported how they were forced to give up their land without prior and informed consent by intimidation of the security from oil palm companies with the support of police officers and military officials. Another member reported how the plantation establishment has destroyed their ancestral grave which is located in forested groves that is of cultural significance to indigenous people. Another member expressed the loss of social cohesion

among the community after the companies adopt the strategy of hiring local people as the company's security guard. Some other members confirmed that diseases are spreading because the streams from which they used to obtain drinking water are now contaminated from fertilizer, herbicides, and palm oil mill effluents. Once their land has been taken over for plantation purposes, local people have little choice but to work as casual day laborer on the oil palm estate, a situation which is more akin to slavery than employment relationship. These conditions reflect how palm oil industry has brought negative impacts to the social fabric of affected local communities.

3.4 Socio-economic repercussions

Although not totally meeting the stakeholders' expectation, the gap in the socio-economic repercussion is relatively small. This reflects that society agrees that palm oil industry has brought positive socio-economic impacts to the society, such as its contribution to local employment (criterion D1) and economic development (D2).

With a remarkable growth of oil palm area in Indonesia, from about 250,000 ha in 1978 to more than 6 million ha in 2008, undoubtedly that palm oil industry is an important generator of employment. Estimates of employment in oil palm cultivation in Indonesia vary from 1.7 to 3 million jobs. However, it must be noted that the structure of the palm oil industry in Indonesia is dominated by operations in upstream production that is from plantation to CPO and/or palm kernel oil (PKO). The CPO and/or PKO are supplied to larger trading and export-orientated companies for further processing of derived products, including biodiesel. Despite the large number of jobs, the quality of job being created is questionable.

Contrary to the expectation, in this study, society does not view palm oil industry as a potential threat on social cohesion/horizontal conflict (D3) and food security (D4). A possible explanation for this might be that the respondents have difficulty in understanding connection between on palm oil industry and these two impacts due to the complex nature of these relationships as opposed to other impacts assessed in this study. For instance, the food security issue could not be noticed as an impact of palm oil until one analyzes the trend of land transformation of arable lands into oil palm plantations, which is beyond the attention of general public. Thus, it is important to conduct more detailed study regarding these two specific criteria.

3.5 Governance

Value chain actors in this study perceive that governance aspects have pretty much met their expectations as seen by its relatively low gap. This implies that value chain actors are satisfied with public commitment to the sustainability of their businesses (criterion E1) and fair competitions among actors (criterion E2). Nevertheless, small dissatisfaction is spotted in the corruption aspect (E3). It is generally understood that oil palm plantations, upstream to the palm oil industry, have been backed by Indonesian government with a view to gaining foreign exchange and securing the employment. Recently, Indonesia has also seen a series of transformations in the regulatory regime with decentralization reform that can be seen as a factor for plantation development in Indonesia. Despite these, efforts to mitigate the increasingly large-scale pollution associated with agro-industrial development and to address the wider socio-economic implications will need to be better crafted.

4 Conclusions

Throughout this study, it is possible to deliver an appropriate set of social criteria that is useful to assess the sustainability of biofuel, particularly palm oil biodiesel (see Table 1). A weighting system using a systematic expert rating has also employed to improve the applicability of these criteria for a multicriteria decision analysis.

Exploitative labor relations, alienation, and other negative impacts on the well-being of local/tribal communities are the most noticeable social hotspots that prevent the sustainability of palm oil biodiesel (see Fig. 2). These social hotspots reveal the fact that the current state of the development in palm oil industry is not socially equitable. The local community and indigenous people are the most vulnerable and eventually bear these social costs. These scientific findings are consistent to other reports published by activist groups (Colhester et al. 2007; Friends of the Earth, LifeMosaic, and SawitWatch 2008).

If palm oil biodiesel is to be produced sustainably, these significant social impacts must be addressed. Working conditions should be improved by strengthen the regulations regarding the casual daily laborer, such as improvements on wage and benefits, health and safety standards, and rights for collective bargaining.

Concerning the negative impacts on the well-being of local/tribal communities, it is absolutely necessary for the government to take the measures to fully recognize and protect the rights of the tribal communities who are threatened by the expansion of oil palm plantations. Such measures may include the enactment of legislative and administrative laws that include customary land ownership as a part of Indonesian legal system to give

full respect to the recognition and protection of customary rights of tribal peoples, which is in line with the United Nations Declaration on the Rights of Indigenous People (UN 2008). Because the local/tribal community already practices sustainable forestry, as they have historically relied on forestry resources for their livelihood, enactment of such laws will promote the local/tribal communities as active participants in sustainable forest management as well as allow a continuous legal access to their forest resources.

Furthermore, in order to continue the positive socio-economic benefits of palm oil industry, it is important to promote further oil palm plantations through smallholders rather than large scale industrial estates, because the development benefits will be larger when communities retain their land and directly involve as oil palm grower, compared to when they sell their land to estate companies. It is also important to strengthen the structure of palm oil industry by transitioning from downstream processing oriented to a more integrated one, which also aids as an incentive to acquire technical and scale efficiencies.

Much of the responsibility for the situation in producing countries seems to lie with the local/state governments. However, the problems detected in this study could also be addressed in several ways by the participation of other stakeholders in driving the policy that ensures sustainable pathways of palm oil biodiesel. For instance, consumers/importers can impose actions to the governments in producing countries to ensure palm oil companies in their respective countries have been addressing all critical sustainability issues (e.g., using certification mechanism). To this end, it is absolutely relevant to educate the consumers about the impacts of palm oil biodiesel on sustainability to engage the demand-side pressure.

While the consumer stakeholder is excluded in this study, this study was able to reach the upstream processes of the palm oil biodiesel supply chain, which are the very significant processes in the entire palm oil biodiesel supply chain. Further research should be focused on the downstream processes, which should include consumer stakeholders. Additionally, voices of large-scale importers such as the European Union or the USA trade organizations should be incorporated and put as stakeholder in the clustered "value chain actor".

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